

ART. XIV.—*On the Condition of the Blood after Death from Snake-Bite*, as a probable clue to the further study of Zymotic Diseases, and of Cholera especially. By GEORGE B. HALFORD, M.D.

[Read 10th June, 1867.]

MR. PRESIDENT AND GENTLEMEN,

On the 25th of last April I addressed a letter to the Editor of *The Argus*, of which the following is part:—

“When a person is mortally bitten by the cobra-di-capella, molecules of living ‘germinal’ matter are thrown into the blood and speedily grow into cells, and as rapidly multiply, so that in a few hours millions upon millions are produced at the expense, as far as I can at present see, of the oxygen absorbed into the blood during inspiration; hence the gradual decrease and ultimate extinction of combustion and chemical change in every other part of the body, followed by coldness, sleepiness, insensibility, slow breathing, and death.

“The cells which thus render in so short a time the blood unfit to support life, are circular, with a diameter on the average of one seventeen-hundredth of an inch. They contain a nearly round nucleus of one two thousand-eight-hundredth of an inch in breadth, which, when further magnified, is seen to contain other still more minute spherules of living ‘germinal’ matter. In addition to this, the application of magenta reveals a minute coloured spot at some part of the circumference of the cell. This, besides its size, distinguishes it from the white pus, or lymph corpuscle.

“Thus, then, it would seem that, as the vegetable cell requires for its growth inorganic food and the liberation of oxygen, so the animal cell requires for its growth organic food and the absorption of oxygen. Its food is present in the blood, and it meets the oxygen in the lungs; thus, the whole blood becomes disorganised, and nothing is found after death but dark fluid blood, the fluidity indicating its loss of fibrine, the dark colour its want of oxygen, which it readily absorbs on exposure after death.

“Let it not be thought that microscopic particles are unable to produce such great and rapid changes. It is well known, and I have frequently timed it with my class, that a teaspoonful of human saliva will, when shaken with a like quantity of decoction of

starch, convert the whole of the latter into sugar in a little less than one minute. If ptyaline, the active principle of saliva, exerts this power at most in a few minutes, then surely the active principle of the secretion of the serpent's poison-gland may exert an infinitely greater power in as many hours.

"It results, then, that a person dies slowly asphyxiated by deprivation of oxygen, in whatever other way the poison may also act, and so far as the ordinary examination of the blood goes, the *post-mortem* appearances are similar to those seen after drowning and suffocation.

"I have many reasons for believing that the *materies morbi* of cholera is a *nearly allied animal poison*. If so, may we not hope to know something definite of the poisons of hydrophobia, small-pox, scarlet fever, and indeed, of all zymotic diseases?

"I am, Sir, your obedient servant,

"GEORGE. B. HALFORD. M.D.

"April 25.

"P.S.—At the suggestion of my friend Dr. Neild, I am going to try the inhalation of oxygen as a remedy."

My reason for addressing *The Argus* was to obtain immediate and extensive circulation, copies of the letter having been sent home by the mail the following day. I hope the subject will appear of sufficient general importance to have warranted my so doing.

The letter you will perceive contains a statement of facts, upon which is built the hypothesis of the cause of death after snake-bite, and of the probable origin of cholera from an allied animal poison. I proceed now to state those facts to the Society, and to develop the hypothesis which I put forth, not as the whole truth, but as a means by which the action of animal poisons on the body may perchance be arrived at.

A gentleman, aged thirty-three, was bitten on the finger by a cobra-di-capella. About three hours afterwards he was discovered moaning by Mr. Fielder, who states: "I went to his side and found him perspiring freely, face flushed; the third finger of the left hand punctured at the knuckle of the second joint, from which a dark fluid oozed freely; finger swollen and turning black and purple, discoloration extending to the back of hand, which was puffed up, having a glassy and livid appearance; thence upwards and nearly to the elbow, redness and irregular streaks and patches defined the track of mischief. I applied the ligature at first sight close above the elbow, and gave brandy, also washed the

wound with the same until medical assistance was sent for." About half an hour after the discovery, Mr. Fitzgerald says: "I found the patient in a state of stupor (like a person under the influence of a narcotic). He had a fair pulse, about 80. The extremities were below the natural temperature, and the surface of the skin generally covered with a cold moisture. The power of speech was lost: when attempting to speak the words seemed so thick that they could not be understood." In eight or ten minutes after this, although stimulants were freely given, the symptoms changed very much. "The patient had lost all consciousness, and his face and lips were livid; respiration scarcely to be noticed, and pulse difficult to detect." He was then removed to the hospital, where he died in about half an hour; Mr. Fitzgerald remarking that "his respiration stopped from ten to fourteen minutes before the heart's action." Dr. Moussé says, "On arriving at the hospital he was in a dying state, the general appearance was livid, and the temperature of the body so lowered that it could be felt by the touch."

The next day a *post-mortem* examination was made, at which I was invited to be present. Nothing abnormal was discovered except fluid alkaline dark blood and some congestion of the lungs. I took a little of the blood from the spinal canal, and placed it under the microscope in Dr. Moussé's room. It appeared to contain a very large quantity of colourless corpuscles, of large size. With this observation I left.

The same evening the cobra was brought to me. I made it insensible with chloroform, and turned it into a jar of spirit till the next day, when I removed all the poison I could, about half a drachm or more, and reserving a little for microscopic examination, injected the remainder beneath the skin of the abdomen of a full sized dog. The animal died after the usual symptoms during the same night.

POST-MORTEM EXAMINATION.

The subcutaneous tissue was infiltrated with dark serum, extending nearly as high as the axilla and down to the thigh; outwards nearly as far as the spine, inwards a little beyond the *linea alba*.

No evidence whatever of inflammation or disease of any internal organ or of the lymphatics.

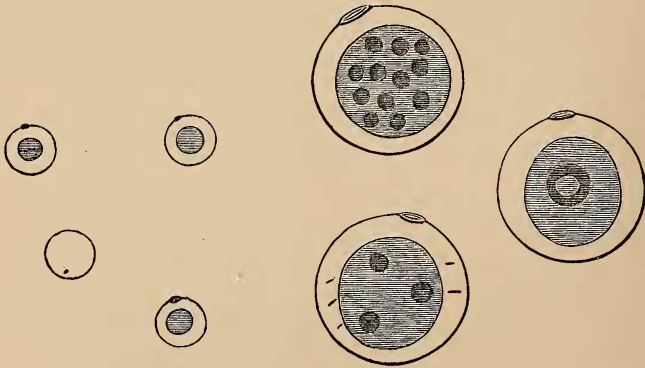
The blood was in parts in a semi-fluid, in parts in a fluid state. No fibrinous coagula anywhere.

MICROSCOPIC EXAMINATION OF THE BLOOD.

I was at once struck with its resemblance to the blood of the man I had seen the day before at the hospital, and now with my own instrument and appliances I spent the whole of two days (it being holiday time) examining this blood. What I hastily took for white corpuscles at the hospital with a strange instrument and no conveniences for quiet observation, turned out to be nucleated cells of a perfectly circular form, with a diameter on the average of $\frac{1}{1700}$ inch. The nucleus nearly round, $\frac{1}{2800}$ inch broad. Besides this I detected on the second day, after applying magenta, a minute spot at some part of the circumference of the cell. This remarkable spot, when once seen, was distinctly visible in all.

PLATE I.

Foreign cells seen in the blood of the dog poisoned by the venom of the Cobra di Capella.



x 400 diameters.

x 1100 diameters.

Copied from the Author's drawings, by Dr. Neild.

Of these cells there must have been many millions ; they were present in the blood of every part of the body, but in much greater quantity in the dark congested parts of the lungs. None, however, were detected in the fluid of the thoracic duct.

EXAMINATION OF THE POISON.

It was distinctly acid, nearly as thick as fluid honey, becoming more so on exposure. Under the microscope, besides epithelium and much molecular matter, it contained nucleated cells of the same size as those I have described as found in the blood, but I saw no spot, or macula, in the circumference, neither had I at this time detected any in the cells found in the blood, and by the next day my assistant had unknowingly thrown away my little drop of poison, and the cobra being in spirit, with the poison-glands laid open, the form of the cells was destroyed.

We have now to ask the very important question, what are these cells? They differ from the white corpuscles in size and in the presence of the spot, or macula, on the circumference. The diameter of the white corpuscle being, according to Beale, from $\frac{1}{4000}$ inch to $\frac{1}{2500}$ inch; he gives a drawing of one, however, nearly $\frac{1}{2000}$ inch, but the shape is different, and he describes no macula which so eminent an observer could not have overlooked with the $\frac{1}{25}$ of an inch objective. (My own observations were made with a splendid $\frac{1}{4}$ of Ross and the $\frac{1}{20}$ inch of Smith and Beck). Gulliver says the diameter of the white corpuscle is $\frac{1}{2800}$ of an inch, and Carpenter $\frac{1}{3000}$, seldom larger or smaller. Mr. Ralph figures it about $\frac{1}{2500}$ of an inch.

My own observations on the blood have been very numerous, and as regards the white corpuscle, its size, and I believe also its state of maturity, vary very much. The average being in man $\frac{1}{2400}$ of an inch, in the dog $\frac{1}{2800}$. When much larger it may be difficult to distinguish it from the new cell. The largest white corpuscles I have ever seen were in the blood taken from the umbilical artery of a pup, while in utero.

But when the white corpuscles abound in the blood, there is usually an increased amount of fibrine also, as in the *Leucocythæmia* of Bennett and *Leucocytosis* of Virchow. The latter author speaks also of their existence in large numbers in cases where there is a diminution of fibrine as in typhoid fever. In these cases of snake-poisoning there was a deficiency of fibrine in the blood allying them, if we are to look upon these cells as white corpuscles, to the leukæmia of fever, in which, according to Virchow, the lymphatics are unaffected.

Are they granular cells of pneumonia? In the first place no pneumonia was found; and secondly, they are unlike them.

Are they pus-cells? All observers agree in stating that there is considerable difficulty in distinguishing well developed pus-cells from the white corpuscles of the blood. The action of reagents upon both being nearly if not precisely identical. Their usual diameter is, according to Paget, from $\frac{1}{2500}$ to $\frac{1}{3000}$ of an inch. Virchow represents them as $\frac{1}{2500}$ of an inch. Hassall figures them $\frac{1}{3350}$ of an inch. Bennett, of Edinborough, makes them larger, *i.e.*, from $\frac{1}{1200}$ to $\frac{1}{2000}$.

Are they large exudation cells? No exudation was discovered anywhere, and they are also different in structure.

What are they?

Their perfectly circular outline, and large nucleus prove them to have grown without impediment, and to have, as evidenced by their numbers, multiplied enormously and rapidly; in other words, living "germinal" matter from the cobra has been thrown into the blood and grown at its expense.

What is the meaning of the macula?

Until further opportunity occurs to me, I would ask, can it be possible that the germ inheriting the qualities of its parent is fed by the blood which tends to make it one of its own corpuscles, but produces instead a hybrid nucleated maculated cell, except for its circular form, like a reptile's blood-corpuscle? or is the macula a more general characteristic of cells than is yet known?

Immediately after the occurrence of the accident which led to the foregoing observations, I endeavoured to procure Australian snakes in order to see the effects of their poison on the animal frame, and, if possible, to find some means of counteracting it. But I have found the winter too far advanced, and have been only able, although applying in many quarters, to procure two very young black snakes.

The snakes were very disinclined to bite, and my desire being great to examine the poison, I killed one for this purpose, and to my regret found very little in either gland. What there was was slightly acid, and consisted chiefly of free nuclei, having generally a translucent circular nucleolus, sometimes two; some of the nuclei and nucleoli were oval. I examined them with the $\frac{1}{4}$ and $\frac{1}{20}$ inch objectives.

PLATE II.

Germinal matter, or free nuclei, from the poison-gland of young Australian Black Snake.



From a drawing by the Author.

Determined not to lose the little poison I had, I minced up the glands and inserted them beneath the skin of the abdomen of a dog. The severe illness and speedy death of one of my children prevented me continuing the inquiry. It was, however, proceeded with by Mr. Lawrence, one of my class, who has been kind enough to forward me the following notes:—

“May 11th, 1867.—Professor Halford inoculated a dog with the poison of a young black snake, about eighteen inches long, by inserting the gland beneath the skin of the abdomen. The same evening he examined a drop of blood from the ear, and found the number of white corpuscles greater than in normal blood, and at least two cells similar to those seen after poisoning by the cobra-di-capella, but of somewhat less size. The dog at this time did not show any very marked symptoms—he had vomited once and seemed unwilling to move about.

“12th.—Professor Halford being unable to continue his observations to-day, I examined the blood. The number of white corpuscles was much increased. After much dilution with solution of magenta, each field presented about twenty-four of these bodies, among which a few of the characteristic cells could occasionally be seen. As regards size, there was not here such a striking contrast between these cells and the white corpuscles as there was in the cobra-case, when a single glance was sufficient for diagnosis between them; but still the nucleus being always single, the presence of the macula and a peculiar clearness of the cell are, I think,

sufficient to prevent the two being confounded together. I drew several under the camera lucida, of which the diameters were from $\frac{1}{2000}$ to $\frac{1}{1600}$ of an inch.

PLATE III.

Maculated nucleated cells, from the blood of the dog which recovered inoculation of the poison of the Australian Black Snake.



× 400 diameters.

From a drawing by Mr. O. V. Lawrence.

The dog at this time (the forenoon) was drowsy, and when compelled to move about did so with difficulty, seeming very weak, especially in the hind parts. His eyes were dull and protruding, and he evinced pain by his doleful looks and by snapping at his hind legs. In the afternoon he was very much worse.

“13th.—Examined carefully the blood from the ear and tail. Number of white corpuscles much less than yesterday, and not one of the other cells to be found. *The blood coagulates much more readily than it did yesterday.* The dog is much better, and except a little stiffness appears to be quite well.”

The observations of Mr. Lawrence are very interesting, and seem to point to the simultaneous disappearance of the cells and restoration to health.

Six days after this, that is, on the 19th, I very carefully examined this dog's blood myself, and found nothing abnormal, none of the white corpuscles exceeding $\frac{1}{2700}$ of an inch in diameter.

The remaining snake I kept constantly before the fire. It, not eating, afforded a very good illustration of *heat being converted into motion*, for it became very lively, and bit a kitten in the foot one afternoon at half-past three o'clock. The kitten died at ten minutes past-seven the same evening. On examination the lungs were not congested. The blood was everywhere dark and fluid; some taken from the in-

ferior vena cava contained many of the characteristic cells, and in that of the saphena vein of the bitten leg were many free nuclei "germinal matter" exactly corresponding to those of the serpent's poison.

PLATE IV.

Germinal matter, or free nuclei, and large maculated nucleated cells from the blood of the saphena vein of a kitten, bitten in the foot by young Australian Black Snake.



× 400 diameters.

From a drawing by Mr. Ashworth.

After this a pigeon was bitten, and died in twenty-two minutes. The blood was not fluid, and none of the characteristic cells were found. It would be impossible to say that in this case none existed, the fluid part was only examined, and therefore there might be such cells in the clotted parts. Want of time, caused by family illness, &c., prevented my examining this case, in fact the case of the kitten and the following were more observed by my students than by myself.

However, the condition of the blood of pigeons bitten by the rattlesnake has been recorded, according to Nysten in *Le Dictionnaire de Medicine*, by Dr. Brainard, of Illinois.

- “1st. Change of shape of the red corpuscles from oval to round.
- “2nd. Abundance of white corpuscles, grouped together in nipple-shaped masses.
- “3rd. Liquid state of the blood in the cavities of the heart from want of coagulation of fibrine.”

It is not improbable the doctor saw similar cells to those we have been describing, taking them, as I did at first glance, for white corpuscles.

Not having then seen the cells in the poison of the serpent as particularly as I wished, I killed the reptile,

and on examining the poison—*of which there was little more than a trace*—found the same free nuclei with nucleoli as in the other, with only here and there an indication of a maculated cell like those seen in the blood. Mr. Lawrence thought he saw one or two, but it is extremely difficult to tell these cells from the serpent's blood-corpuscle, which may have become round by being placed in fluid. In the strange cell the nucleus is larger and the macula also. They were so in the cells pointed out by Mr. Lawrence, but to clear up this point I must wait till next summer. I may mention that a week before this, the snake being very lively, I let it bite a pigeon and a rat, which it did savagely and shook them, but not the least harm resulted to either.

To return to the poison, a minute quantity was inserted into the thigh of a rat; it died in one hour.

The examination of this blood was made by Mr. Ashworth, another member of my class, and his observations were confirmed the same evening by myself.

The blood was everywhere fluid. The following are Mr. Ashworth's words:—

“The large nucleated cells were readily seen if carefully looked for in the uncoloured blood (*i.e.*, without magenta dye), the large cells being three times the diameter of the red corpuscles.

“In the femoral vein of the injected leg were many of the cells and free nuclei, the latter mostly circular, some oval, of a diameter of $\frac{1}{4000}$ of an inch, the exact size, shape, &c., of those of the poison nuclei of the serpent's venom.*

“The blood in the vena cava and vertebral veins contained the same cells and nuclei.

“In the lungs the same cells were found in addition to a large number of white corpuscles.”

* I may mention that in all the cases recorded in this essay in which the foreign cells were seen, accurate drawings were made either by Mr. Lawrence, Mr. Ashworth, or by myself. These were shown at the meeting, and enlarged drawings made from them by Mr. Morton, whom I have to thank for his invariable readiness to assist me with his pencil.

PLATE V.

Germinal matter, or free nuclei, and maculated nucleated cells from the blood of a rat poisoned by the Australian Black Snake.



× 400 diameters.

From a drawing by Mr. Ashworth.

I have collected a few cases of snake-poisoning in order to draw your attention to the state of the blood after death.

Case 1.—Henwood, a soldier, aged 40, was bitten in the finger by a diamond snake of Tasmania, and died 92 hours after. The blood was fluid and dark, and fibrinous clots were nowhere found. On cutting into the lungs very dark fluid blood oozed freely. The absorbents were not affected.

Case 2.—Cartwright, a man bitten by an Australian snake, died twenty minutes after. The whole blood of the body was in a fluid state, not one single clot was observed, nor did it coagulate when exposed to the air. The lungs were healthy, but filled with dark fluid blood, with black patches here and there.

Case 3.—Underwood, a man bitten by an Australian snake. Dark fluid blood, with some thread-like clots, in the right ventricle. The lungs were very much congested, resembling in many parts the patches of pulmonary apoplexy.

Case 4.—A man, aged about 30, keeper of the reptiles in the Regent's Park Zoological Gardens, was bitten on the nose by a cobra-di-capella, and died in 90 minutes. The blood was dark, alkaline, and fluid. The right side of the heart contained blood, the left side none. The lungs were congested.

Case 5.—A powerful man was bitten by an unknown snake. In this case it was remarked that spitting and coughing up of blood followed. The blood had no tendency to coagulate, neither did that which was drawn with the cupping-glasses, *although the breathing was natural, and the heart's action 90 per minute.* He died 24 hours after the bite.

Case 6.—A sepoy was bitten by a cobra-di-capella.

Three hours after the bite blood-spitting occurred. Soon after cupping was resorted to, and seven or eight ounces of blood drawn off, which remained perfectly fluid. Eight hours after the extremities were cold and corpse like. This man ultimately recovered, the medicine being chloroform, arrack, and camphor.

Such being the facts preceding and following death from snake-poison, let us see what problems we have to solve :—

The body is *minus* heat.

The blood is *minus* oxygen.

Ditto *ditto* fibrine.

Ditto *plus* foreign cells.

1st. *The body is minus heat.* Let it be remembered that in death from starvation and in lingering diseases, the temperature of the body is kept up at the expense of the tissues, even of the nitrogenous. In snake-poisoning the bitten man or dog is breathing; oxygen is absorbed, combustion occurs, but where is the heat? Combustion does not take place in the tissues, as is evidenced by the general coldness; the red corpuscles do not convey the oxygen, as is shown by the state of the blood, for, as in cholera, the blood is dark even as it flows through the arteries, and becomes red on exposure to the air. Combustion occurring, the heat that should result is rendered latent, or rather is converted into motion; the molecular motion necessary for the aggregation of the billions of particles constituting the new cell growth. If this view of the loss of heat be correct, then after death, when oxygen no longer has access, *and that contained in the blood is used up*, the molecular forces being arrested, the heat should be again rendered up to the now lifeless body.

I have not as yet had a fair opportunity of making the observation, but a rise of temperature after death from cholera, yellow fever, &c., of seven and of even nine degrees, has been observed, an amount of heat requiring for its production molecular energy or chemical action sufficient, if converted into mechanical force, to raise many tons weight several feet from the ground, or to raise the lifeless corpse higher than our highest building. Tyndall, when speaking of the atoms of water, calls them "giants in disguise." "The force of gravity almost vanishes in comparison with molecular forces;" the pull of the earth upon a pound weight as a mass, is as nothing compared with the mutual pull of its own molecules."

I shall have presently to refer to one authentic case of cholera, in which a new cell-formation existed in the blood. Is it unreasonable then to assume that possibly in cholera and yellow fever the heat during life may be replaced by molecular motion, and be re-manifested when that motion is destroyed, as after death? I think at least physicians must no longer simply record, but endeavour, by as rigid an adherence to physical laws as possible, to account for the rise of temperature after death from cholera or any other disease.

2nd. *The blood is minus oxygen.*

The gas has been absorbed but appropriated by the new cells, the red corpuscles carry it not to the tissues, or at least not in sufficient quantity, and the blood soon becomes charged with carbon. Dr. Marcet states in the *Lancet*, of February 2, 1867, that the exhalation of carbonic acid from the lungs requires a certain temperature, and that as the heat of the body falls so the carbonic acid tends to accumulate in the blood. Part of the oxygen inhaled probably enters into the composition of the growing germinal matter, constituting the new cell-formation, the remainder uniting to form carbonic acid and water.

Now, if we suppose that the blood is deprived of one quarter of its oxygen only, death would speedily result, for the late Dr. Snow found that if an animal breathes an atmosphere containing from $10\frac{1}{2}$ to 16 per cent. of oxygen, instead of the normal quantity, 20 per cent., it soon dies, although provision is made for the removal of the carbonic acid as fast as it is formed.*

The oxidation of the food in the blood and of the tissues is transferred from the bitten man to the foreign cell, which is equivalent to saying, that *animal power is transferred from the one to the other.*

It is wonderful to reflect how long this power or energy may be retained by living "germinal" matter. Seeds grow after ages of inaction. Vaccine matter is dried and carried all over the world; the poison of the cobra has been inoculated and caused death after having been kept ten years.

3rd. *The blood is minus fibrine.*

Of this there is no doubt, and it is interesting to inquire how far this may be dependent upon oxygenation.

The blood is dark and fluid in all cases in which it has

* Carpenter's *Human Physiology*, Sixth Edition.

been deprived of oxygen, as in suffocation and drowning. On the other hand, when animals have breathed an excess of oxygen, the blood coagulates with remarkable rapidity.

Dr. Gairdner found the proportionate amount of fibrine corpuscles and albumen in the arterial blood of healthy rabbits to be—

Fibrine,	1·65
Corpuscle,	82·35
Albumen,	46·30

When other rabbits were made to breathe pure oxygen for half an hour, the proportion was—

Fibrine,	2·40
Corpuscle,	69·56
Albumen,	40·23

4th. *The blood is plus millions of cells.*

So large an amount of cells produced in so short a time fully accounts for the disorganization of the blood and death. But death occurs sometimes so rapidly, that it would appear impossible for cells to be formed in so short a time. In which case we must consider the change in the blood to be brought about as rapidly and in the same manner as the change from starch into sugar under the action of ptyaline. It seems our only explanation. Quite as mysterious, indeed, is the more rapid change which takes place in the condition of the blood after death by lightning. A case has lately occurred at home in which “the great veins were distended with very dark blood, everywhere perfectly fluid—not a symptom of a clot, neither did it show the slightest tendency to coagulate after its escape.” It does not however follow that a few minutes is too short a time for the blood to lose a quantity of oxygen sufficient to destroy life. For the germinal matter, if not checked in its growth, gains strength as it proceeds, *vires acquirit eundo*, and deprivation of oxygen for a few minutes is always fatal.

Again the presence of these cells leads us to ask whether they are in any way connected with fermentation; if so it would strengthen, if not establish, the theory that fermentation is never excited except under the influence of microscopic organisms, and that, as affirmed by Pasteur and others, each particular organism sets up a particular species of fermentation, and we might add of animal or vegetable poisons its peculiar species of disease, and further, that in all zymotic diseases these particular organisms should

be diligently looked for where indeed their presence has long been suspected, viz., in the blood.

Respecting the development of animal and vegetable life in different media as the probable cause of the various processes of fermentation, Sir Henry Holland observes : " It is one of those curious questions where doubt exists as to the respective conditions—which is *cause*, which *effect*, in their mutual relation? Such doubt is generally solved in the event by some simple and single observation, deciding not merely the particular problem, but opening a way to knowledge beyond."

I now pass to consider Cholera. Discarding contradictory accounts, I shall quote principally from the last edition of Aitkin's *Science and Practice of Medicine*, and from Holland's *Medical Notes and Reflections*, and Watson's *Practice of Physic*.

Dr. Aitkin says : " The remote cause of this disease is unquestionably a poison ; for at no period has a person in good health in this or any other country been known to become in a few minutes shrivelled up, his whole body to be of an icy coldness, his face and extremities to turn purple, and, with or without vomiting of a peculiar fluid like rice-water, to die in a few hours, except under the influence of a poison." " The doctrine now, therefore, universally accepted regarding the pathology of cholera is that a poison has been absorbed, and infects the blood ; that after a longer or shorter time it produces a primary disease of the blood ; that it undergoes enormous multiplication in the living body of the cholera patient, as a result of the morbid process so established ; and that changes are induced in the function of respiration directly consequent upon this alteration of the blood."

This is, you observe, the pathology of snake-poisoning, so far as I can apprehend it.

Sir Henry Holland says : " Singular though the symptoms of cholera are, in their suddenness and fatality, they offer no difficulty which does not equally belong to other kindred diseases. We may even go a step further and affirm that the notion of an animal virus, applied to absorbing surfaces, and engendering the disorder by entering into the circulation, is that which on the whole best accords with the character of the disease, and with the analogies most obvious to other morbid affections. We have many proofs of the power and virulence of different poisons of this class,

and of the remarkable changes they produce on the nervous system and the blood ; often so speedily after their absorption that all observation is frustrated in seeking to follow the train of events, and speculations equally at fault in attempting to find a theory for them. The action of the morbid cause of cholera seems to have most kindred with these poisons ; the change which takes place with such rapidity in the properties of the blood being, as I think, the great feature of the disease, the basis probably of all the other symptoms."

We have seen that loss of heat and rapidly succeeding death, attended with fluid dark blood, are the principal features of severe snake-poisoning.

In cholera, Dr. Aitkin says : "The phenomena resulting from the changes in the blood are the proper and distinctive symptoms of the disease, and the term 'algide,' first used by the French pathologists, very happily designates one of its most remarkable and constant symptoms, viz., the diminution of animal heat. The algide symptoms, in truth, essentially constitute the characteristic phenomena of this disease. In proportion to them is the malignity and rapidity of the case. They afford the only measure of its severity, and from them only can a correct prognosis be formed. The vomiting, purging, and cramps are now considered as non-essential phenomena ; for authentic cases of cholera are on record, by several of the most eminent writers on this subject, entirely divested of these symptoms ; and the suddenness with which the poison sometimes extinguishes life is extremely remarkable. When the cholera reached Muscat, instances are given in which only ten minutes elapsed from the first apparent seizure before life was extinct." Dr. Gavin Milroy relates that at Kurrachee, in 1845-6, "Within little more than five minutes hale and hearty men were seized, cramped, collapsed, and dead." "Instances of death taking place in two, three, four, or more hours are extremely common."

Sir Thomas Watson observes of the London epidemics of 1832, 1849, and 1853 : "In fatal cases death took place sometimes in the course of two or three hours ; and it was seldom delayed beyond twelve or fifteen." Dr. James Johnson says : "In rapidly fatal cases there is a great exhaustion of the power of generating heat ; the air expired from the lungs becomes progressively colder ; and so do all parts of the body until they are merged in that of death."

Now, the *post-mortem* appearances in those who have died in the severe or cold stage of cholera present nothing but an altered state of the blood, which is usually black and fluid; indeed, blood drawn from an artery in this stage is black, and Schmidt has found the amount of oxygen contained in the blood corpuscles lessened by one-half.

In a former part of this paper I have said that the snake-bitten man breathes, oxygen is absorbed, combustion occurs, but where is the heat? Referring to cholera, Dr. Parkes evidently had similar thoughts, he says: "But as the mechanical part of respiration remains perfect, and as there is no impairment in the voluntary command of the respiratory muscles, and as the heart evidently beats in many cases till stopped by the want of blood on the left side, we are compelled to look for the cause of such arrest of the circulation in the only remaining element of respiration, namely, in the blood itself."*

I may allude here to those singular muscular contractions which occasionally happen after death by cholera, and quote from the writings of my late friend and colleague, Fred. W. Barlow. You will find his papers in the *London Medical Gazette* from 1848 to 1850. He mentions instances of convulsions in India after death by cholera in the corpses of soldiers, which were so violent that their comrades, "in order to calm the timid, bound the limbs to the bed-frame." Again, "A gentleman who died in 1832 of rapid cholera, was turned after death completely on the side by a strange and forcible combination of muscular action." And "muscular contractions, after death, took place to a remarkable extent in a man who died from cholera at Grosvenor-place, in Bristol. The fore-arms were powerfully flexed, and the hands approximating, gave the attitude of praying to the body. No other parts were affected." Lastly, "A young man died of cholera. In ten minutes (while I, Mr. N. B. Ward, of Clapham, was talking to his bereaved mother), I was quickly summoned by the nurse, who told me that my patient was not dead, as she had seen him move. On my return to his bed-side, I found him as I had left him, without pulsation or respiration. In two or three minutes, however, I was almost as astonished as the nurse had been, at

* "Though the passage of the blood through the lungs has been free, its natural change is interrupted by cholera."—Dr. James Johnson on *The Influence of Tropical Climates on European Constitutions*.

seeing the eyes of my dead patient open and move slowly in a downward direction. This was followed, a minute or two subsequently, by the movement of the right arm (previously lying by his side) across the chest. There was likewise a slight movement of his right leg. The motion of the eyes occurred but once; those of the limbs were repeated to a greater or less degree four or five times, and fully half an hour elapsed before they entirely ceased. These movements were not by such fits and jerks as are usually the result of spasmodic action."

Dr. Bennet Dowler, of New Orleans, mentions the case of an Irishman, aged twenty-eight, in which, not long after death from yellow fever, the left hand was carried by a regular motion to the throat, and then to the crown of the head; the right arm followed the same route on the right side; the left arm was then carried back to the throat and thence to the breast, reversing all its original motions, and finally, the right hand and arm did exactly the same.

Dr. Dowler proved, by completely separating limbs which exhibited these movements from the trunk of the body, that the influence of the nervous system was not in any degree essential to their production.*

Now, admitting that *post-mortem* movements have been seen after death by apoplexy, &c., yet they have never been of the character described after death by cholera and yellow fever. If it could be once proved that the symptoms of cholera were due to the presence of a new growth in the blood, *molecular or cellular*, then seeing the close relation that exists between the muscular fibres and their capillaries, and between the latter and the components of the nervous centres, it would not be difficult to trace these *post-mortem* muscular movements to molecular changes still going on in the blood, changes which I have before alluded to as producing heat, and now apparently motion.

I am proud to bring the thoughts of my late friend, W. F. Barlow, in unison with my own. He says, "There is some stimulus or other, though we know it not, which irritates the muscles after death from cholera. Is it possible that changes in the blood go on, and stimulate their fibres, or the minute branches of the motor nerves which ramify therein? Further inquiry may one day solve what is complex now, by finding out circumstances necessary to an

* Carpenter's *Human Physiology*, Sixth Edition.

explanation, but as Mr. Paget remarks, the problem is too difficult while the data are so few and the unknown things so many."

I must however say, I have met with no record of such movements after death by snake-bite, but at the same time the observers have been few and their attention not directed to any phenomena occurring soon after death.

I must now bring before this Society a remark made to me by Dr. Moussé, of the Melbourne Hospital. It was to the effect that the man bitten by the cobra when brought to the hospital was like one in the cold stage of cholera, and at the *post-mortem* examination he said that, with the exception of not being so thick, the blood was just like that of a cholera patient. Of cholera Dr. Moussé has had much experience.

I now come lastly to the remarkable and solitary case of cholera to which, when speaking of the presence of foreign cells in the blood of the snake-poisoned man, I said I should refer. Dr. James M. Cowan, in the *Edinburgh Monthly Journal*, observes of the body of a woman who had died of cholera, "there was not a single morbid appearance which could be held as accounting for the cause of death," but "on examining a drop of blood under a power of 240 linear diameters, in addition to the red and white corpuscles were numerous other bodies, which could not fail to attract notice, generally circular in shape; some however oviform; a few caudate, and composed of a well defined membrane, not at all puckered, enclosing one or two distinct granules. These were very small, quite round in form, and possessed of clear centres. They appeared to be attached in general to one of the extremities of the circumference of the corpuscle; in some cases it was difficult to say whether they were adherent to its interior or exterior." The doctor was totally unable to account for their appearance.

But other observers, such as Virchow, have said that there is an increase of the white corpuscles in the blood of cholera patients. Can it be possible that this eminent man has mistaken foreign cells for the white corpuscle? I think not. I should rather suppose he speaks of the observations of others, and yet it must be remembered that on my first hasty examination of the snake-poisoned blood I took the new cells for white corpuscles, but afterwards, with my own instrument, immediately saw my mistake.

It cannot be unreasonable to suppose that as both the

symptoms and *post-mortem* appearances in severe cases of cholera and snake-poisoning are nearly identical, they may have a *kindred* origin. Certainly the facts before us urge us to a further and searching examination of the blood in cholera. If the cells described by Dr. Cowan should again and always be found, the probability of animal poison as the cause of cholera would be greatly strengthened.*

This may provoke a smile. I put it forth as hypothesis, perhaps fanciful hypothesis, and yet if we consider that the dried poison of the cobra has been kept for ten years and then destroyed life by inoculation, and remember that the home of cholera and of the cobra and other venomous reptiles is India, and that millions of reptiles die yearly, and that as pollen is carried from place to place by insects, so may this dried poison be, or carried into the upper currents of the air, and subsequently inhaled—for the lung has no thick cuticle to be pierced, and therefore no poison-fang is needed—and kill a man in a little more than five minutes, or if not kill so soon, in addition to the gradual robbing of animal heat, produce by its presence in the capillaries of the muscular system those fearful cramps that follow the cold stage and the *post-mortem* movements before alluded to.† I say, if we consider these things, coupled with the *total darkness* in which we dwell respecting the origin of this fearful disease, the smile that at first it is impossible to repress soon passes away, and we are driven to think seriously of the presence of some animal poison at least. I do not think this hypothesis more unreasonable than that some years ago put forward by one of our most eminent writers, viz., Sir Henry Holland, “which looks to animalcule life, diffused by the atmosphere or by man, as the source of the disease—a form of life not cognizable by our senses, or other present means of research, but nevertheless producing a virus which acts noxiously or fatally on the body of man.”

Time will not permit me to say more than just allude to the probability of yellow-fever and most zymotic diseases

* By some it may be asked, May not these have been vegetable cells? Indeed, the line of demarcation between animal and vegetable organisms is becoming daily less definable, and it is even said that rapidly-growing fungi play the part of animal cells, *i.e.*, absorb the organic matters on which they grow, and yield up carbonic acid.

† Some people, arguing about infection, speak as though poisons were dissolved in the atmosphere, and everybody must inhale them, whereas they are suspended or diffused, whereby A may be infected and B may not.

being due to animal poisons, and also that opprobrium, if I may so call it, of surgery, pyæmia. Even so lately as February last, Mr. Savory says: "The worst cases of pyæmia, those in which death is most rapid, reveal afterwards the least sign of local disease. Indeed, in the very worst cases there has been no time for local mischief to supervene. The whole mass of the blood is so poisoned and spoiled that it kills outright. In these cases the blood is found unnaturally dark and fluid, with few, large, black, soft, and imperfectly formed clots. Its power of coagulation is evidently impaired."

Lastly, as suggested to me by my friend Dr. Bayldon, are the cells seen in leucocythæmia, white corpuscles or other animal cells?

I would advocate a thorough re-examination of the blood in all these cases, and strongly recommend the use of magenta dye in every instance.* In support of my views I will quote the words of a great living physiologist, M. Claude Bernard: "In all *post-mortem* examinations the state of the blood more especially deserves our attention. Towards this object the energies of all our physiologists ought to be mainly directed. Organic chemistry, however, is unfortunately not in an advanced state, especially as regards the constituent principles of the animal organization; and chemical analysis must, therefore, be in a great measure left aside, when the properties of the blood are the subjects of investigation; in other terms, a physiological analysis is in this respect far preferable."

Further investigation must be deferred till the summer, and in the meantime I cannot but think that a wide field for research into the molecular condition of the blood in disease has been opened. Although it must be confessed that if any light is thrown by these researches upon the origin and mode of action of animal poisons, it is only sufficient to show us the great darkness that is before us. In bringing before the Society the hypothesis of the abstraction of oxygen from the body by the growth of germinal matter in snake-bite, and possibly in cholera and many other diseases, I have done so in no vain mood, but with a sincere desire to add my mite to the discovery of truth, and even should all turn out error, as possibly it may, the labour will not have been for me, and I trust not for others, in vain.

* The proportion I find most generally useful for histological inquiry is one drop of Power's or Judson's dye, to twenty of distilled water.

One word as to the influence of large doses of alcohol: In the *Australian Medical Journal* of April, 1859, a case of snake-bite is recorded by Dr. Doughty, in which two bottles of brandy were drunk without the slightest symptoms of intoxication; and Mr. Gillbee mentioned to me a case in which he gave a girl, aged fourteen, three bottles without intoxication, and she recovered.

These cells being of a rapid growth, have probably a brief existence, recovery from snake-bite being usually sudden. Alcohol, as you know, has powerful attractions for oxygen, and being immediately absorbed by the veins of the stomach, if it should engage the oxygen the cells would perish and recovery ensue.

The inhalation of oxygen must be quite an experiment, some authors, as my former eminent and much respected teacher, Dr. Bence Jones, thinking the gas essential to cell life, others of authority, as Dr. Beale, deeming it prejudicial.